

SESSION III

Empirical Models of Compliance and
Performance of Enforcement Agencies

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PRELIMINARY DRAFT
DO NOT QUOTE

ENFORCEMENT AND COMPLIANCE
IN THE
MASSACHUSETTS LOBSTER FISHERY

by

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Evaluation of enforcement programs ultimately depends on empirical measures of compliance and the factors which explain the incidence of compliance. Measuring compliance and its determinants is fraught with non-trivial problems. First, official data only partially measure non-compliance and usually cannot be used to estimate the overall incidence of compliance. Second, since compliance usually is a socially desirable trait, self-reports of compliance behavior are likely biased. And third, individuals' perceptions of certain conditions (e.g., the chance of being detected) may be more relevant than actual conditions when explaining compliance behavior.

In this paper we report on our recent attempt to overcome these and other problems. The subjects of our study are fishermen in the inshore commercial lobster fishery of Massachusetts. A survey of these fishermen was conducted during April and May, 1987, to collect basic data on enforcement and compliance in the fishery.

The purpose of this paper is two-fold: one, to present the methodology used for collecting the data and, two, to report our measures of compliance and of the determinants of compliance.

The paper is organized as follows. In the next section we describe the lobster fishery and the fisheries law enforcement program in Massachusetts. The second section explains the analytical framework and data

THE FISHERY AND ENFORCEMENT PROGRAM

Lobster is the most valuable inshore fishery in Massachusetts. In 1986, reported landings of lobster totalled nearly 15 million pounds valued at over 937 million. Approximately 88 percent of these lobsters were caught in inshore waters by 1400 fishermen with commercial inshore lobster licenses.

The fishery has been subject to a limited entry program since 1975. From 1975 to 1980 the number of inshore licenses was limited to about 1400, including hardship cases. In 1981, statutory changes allowed the number of licenses to increase. By 1986 there were approximately 1800 inshore commercial, 200 seasonal commercial, 700 offshore commercial, and 11,000 non-commercial licenses issued.

The Division of Environmental Law Enforcement is charged with enforcing Massachusetts fisheries laws. Among other things, these laws (i) set a minimum legal size for lobster (3 3/16 inches carapace length), (ii) prohibit the removal of eggs from lobsters and require egg-bearing lobsters to be immediately returned to the waters from which they were taken, (iii) prohibit anyone other than the owner from handling, destroying or molesting any lobster trap, and (iv) require a permit to possess and sell lobsters in the state. The Division enforces lobster and other marine fisheries regulations

outcomes: (1) the fisherman may be found not guilty by the court; (2) the court may dismiss the case or continue it indefinitely; (3) the fisherman may plea bargain and settle out of court on a penalty negotiated with the Enforcement Division; (4) the fisherman may plead nolo contendere and place himself at the mercy of the court; and (5) the court may find the fisherman guilty of a violation. Penalties are invoked for outcomes (3), (4) and (5). The range of penalties include imprisonment, forfeiture of vessel and gear, suspension of one's license to fish (temporary to permanent), and monetary fines.

This series of possible outcomes following a violation creates a "chain of deterrence" that is the essence of the enforcement program. The chain is illustrated in Figure 1.

METHODS

The basic model for evaluating a fisheries law enforcement program is developed in Sutinen (1986). In the model, compliance directly affects the size of the fish stock which, in turn, directly affects benefits from the resource, ceteris parabis. The incidence of compliance is directly related to the perceived probability of detection and conviction and the penalty for non-compliance, and inversely related to the expected gain from violating a regulation. The perceived probability of detection and conviction, in turn, is directly related to the resources and practices of the enforcement program. Penalties are assumed to be determined by a court in conjunction with the enforcement program. In this context, enforcement may be said to induce rather than produce compliance, since it affects the incentive structure (i.e., expected gains and losses) faced by individuals when deciding to comply or violate a regulation.

Data Collection

Primary data was collected to develop estimates of the variables for the compliance framework. The only secondary data available is the official data on detected violations maintained by the Division of Environmental Law Enforcement. The secondary data was rejected as a sole source because it is biased and incomplete. As explained

Clearly, in our survey, which inquires about a person's illegal behavior, the potential for social desirability bias affecting the data is great. To further minimize this bias we used the method of proxy subjects in the survey. That is, instead of asking a person about his/her compliance behavior, we asked respondents to report on another person's compliance behavior. Of course, the other person's anonymity was maintained. In his review of methods for coping with social desirability bias, Nederhof (1985) identifies the proxy subject's approach as yielding satisfactory data on behavior. The randomized response technique, currently a popular approach for coping with social desirability bias, was determined to be impractical for this survey.

The questionnaire was developed over a period of two months during which we consulted regularly with a panel of eight lobstermen. These meetings and several tests of the questionnaire were invaluable in designing our survey instrument. The final form of the questionnaire (see Appendix A) was designed to collect data on enforcement and compliance, and on gear losses, a major concern of most fishermen in the State.

The part of the questionnaire concerning enforcement and compliance was designed to provide the following information:

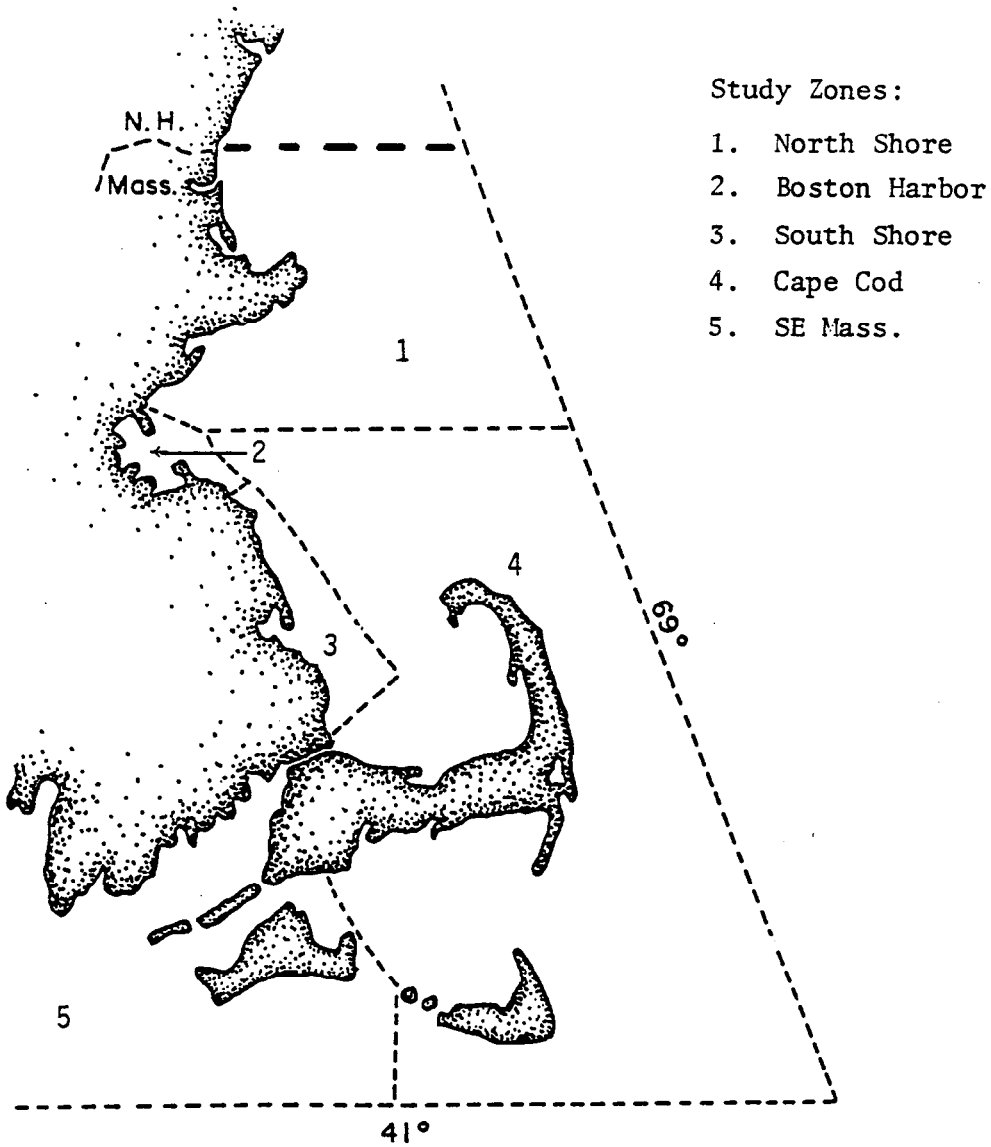


FIGURE 2.
Location of zones for the study of enforcement in the Massachusetts
inshore lobster fishery.

Table 2. Cumulative Number of Questionnaires Received by Week

Week	Cumulative Number received	Percent of Total
1	82	30.1
2	127	47.1
3	230	84.6
4	264	97.1
5	268	98.5
6	269	98.5
7	270	99.3
8	272	100.0

Six different versions of the questionnaire were used. The sample of 800 was evenly divided between questionnaires inquiring about the behavior of fishermen who "usually comply with lobster regulations" and those who "frequently violate lobster regulations." These questionnaires are denoted as complier and violator questionnaires, respectively. The complier and violator questionnaires each has three different versions: one concerns taking and selling short (undersized) lobsters, a second concerns scrubbing and selling egg-bearing female lobsters, and a third concerns molesting other fishermen's gear. The distributions of the returned questionnaires by type and zone are shown in Table 3. The returned questionnaires are fairly evenly distributed across questionnaire types and geographic zones. The variation

RESULTS

The Respondents

Most respondents to our survey claim to be full-time lobstermen (73%), and to have worked in the Massachusetts inshore lobster fishery for more than five years (87%). In terms of where they fish, the respondents are distributed roughly proportionately across the five study zones.

There is near consensus among the respondents that enforcement is not adequate in the fishery (85%). Nearly two-thirds also claim that half or more of all enforcement is carried out by lobstermen alone, i.e. without the help or knowledge of enforcement officials.

Most respondents (88%) report seeing fisheries wardens one or more times working on the water or at the dock and a slight majority (52%) report being inspected at least once in 1986. When inspected, most respondents (79%) state their operations were never seriously disrupted by the inspection. Ten percent of those inspected report being issued violation notices during the year, most (64%) for short lobsters.

Respondents were asked to rate the State's enforcement program in five areas (see Table 4). The lowest rating concerns the Division's methods and use of equipment. Among other things, fishermen argue that the Division's two large patrol boats are too visible and too

groups: those who usually comply, and those who regularly violate. Half of our questionnaires asked each respondent to describe an anonymous complier, and half asked for a description of an anonymous violator. The questionnaires were designed to obtain information on each group regarding their personal characteristics (but not enough to provide identification).

Our objective here was to construct and compare profiles of compliers and violators. This line of inquiry was, and continues to be, largely exploratory. The results regarding five personal characteristics are shown in Table 5. The numbers are the relative frequencies of responses. The selection of these five characteristics was based on the following conjectures:

- (i) Fishermen who are less income-dependent on the lobster fishery have a weaker conservation motive and are more likely to violate management regulations.
- (ii) Lobstermen with fewer years in the fishery are less likely to perceive or appreciate the long-term benefits of management and conservation measures.
- (iii) Younger lobstermen face greater financial pressures (e.g., large mortgage payments) and are more likely to violate regulation for short-run gains.
- (iv) Lobstermen with relatives in the fishery have a greater interest in the long-term health of the fishery and are less likely to violate management regulations
- (v) Frequent violators are often in the fishery for short-term gains only.

evidence does not show strong or sharp differences between compliers and violators on these five characteristics.

Incidences of Violations and Illegal Gains

We estimate that 5 percent of all fishing trips involve landing short lobsters, 8 percent involve scrubbed egg-bearing lobsters, and 9 percent involve molesting other lobstermen's gear. These violations account for estimated annual landings of 614,000 pounds of short lobsters, 618,000 pounds of scrubbed egg-bearing lobsters, and 770,000 pounds from molesting others' gear. The value of these illegal landings is approximately \$5.0 million, or 14 percent of reported landings in 1986. An average violator realizes about \$13,500 in illegal income per year and complier about \$2,400 (see Table 6).

Our estimates of violation rates and illegal gains are based on the survey data in Table 7 and a few strong assumptions. We assume, for example, that the violators and compliers described in the questionnaires are representative of their respective sub-populations. Since we did not collect data on compliers' illegal gains (for a trip with a violation), we assume that when compliers violate a regulation they realize the same gain per trip as that reported for violators. The data on gains per trip is for a typical trip in the peak fishing season and we assume all reported violations take place during the peak season.

Probabilities

In the previous section we examined the extent of violations and the expected gains from those violations. Together with expected gains, the expected losses associated with violations determine the economic incentive to comply. The expected loss for a given violation is the product of the probability of detection and conviction and the penalty. The probability of detection and conviction is a function of the conditional probabilities for the series of outcomes in the chain of deterrence (Figure 1).

The probabilities include the following:

$P_1 = P_r(\text{detection on the water} \mid \text{a violation}),$

$P_2 = P_r(\text{detection at the dock} \mid \text{a violation}),$

$P_3 = P_r(\text{written violation notice} \mid \text{detection}),$

$P_4 = P_r(\text{criminal complaint} \mid \text{violation notice}),$

$P_5 = P_r(\text{no conviction} \mid \text{criminal complaint}).$

The overall probability of detection and conviction is given by

$$P_r(\text{Detection and Conviction}) = [P_1 + (1-P_1)P_2]P_3P_4(1-P_5).$$

In addition to affecting the compliance incentive, this series of probabilities makes explicit how each element or phase of the enforcement program is linked to the others. Given these probabilities, we can then

Table 8. Median Probabilities by Subject and Violation Types

Probabilities	All	Subject Type		Violation Type		
	naïres	Violators	Compliers	Shorts	Egg-bearing	Molesting
Detection						
on the water, P_1	.002	.002	.002	.01	.001	.001
at the dock, P_2	.002	.01	.002	.01	.002	--
Violation Notice, P_3	.50	.50	.50	.50	.50	.50
Criminal Complaint, P_4	.20	.20	.10	.20	.20	.02
No Conviction, P_5	.50	.50	.20	.20	.50	.50
Detection and Conviction	.0002	.0006	.0002	.0016	.0001	.000005

small value of $P_{\Delta} = .02$ for molesting may indicate wardens in the field view the violation as less serious than the other types of violations.

The chance of escaping conviction are perceived as quite good in most circumstances (around .50). For reasons not yet clear to us, lobstermen who usually comply and those cited for taking shorts are perceived as having a higher chance of being convicted in court.

The breakdown of probabilities by zones reveals a few differences, but we have not yet had time to test for the statistical significance of these differences. Both the staff of the Enforcement Division and our advisory group of fishermen provided anecdotal evidence that differences exist in coverage and effectiveness among regions. If we can establish regions where below average weaknesses exist, the Enforcement Division is prepared to reallocate its resources or take other action to eliminate such weaknesses

The overall probability of detection and conviction (calculated using median values) is generally in the neighborhood of .0002, equivalent to odds of one-in-5000. For violation of shorts the odds are greater at one-in-625; and smaller for molesting at one-in-200,000. Zone 4 has modestly better odds than other zones of detection and conviction at one-in-1000.

Similar calculations using means and modes result in

identify potential differences between respondents and non-respondents. Third, we need to compare our results on fishermen's perceptions of probabilities with the actual outcomes recorded in the Division's records. These three sets of limitations will be addressed in subsequent revisions of this paper.

APPENDIX A

32) To the best of your knowledge, has this person EVER done any of the following?

- (1) Taken more than 2 shorts ☐ Yes; ☐ No; ☐ Don't Know
- (2) Taken or scrubbed egg-bearing females ☐ Yes; ☐ No; ☐ Don't Know
- (3) Molested someone else's gear ☐ Yes; ☐ No; ☐ Don't Know
- (4) Fished with an invalid license ☐ Yes; ☐ No; ☐ Don't Know

33) Has this person ever been given a Violation Notice by fisheries wardens?

☐ Yes; ☐ No

34) If you answered yes to any part of question 32, please estimate how many of this person's trips involved the following offenses in 1986.

- (1) Taking more than 2 shorts (NUMBER TRIPS)
- (2) Taking or scrubbing egg-bearing females (NUMBER TRIPS)
- (3) Molesting someone else's gear (NUMBER TRIPS)
- (4) Fishing with an invalid license (NUMBER TRIPS)

35) Please circle the month(s) when this person most likely committed each type of offense in 1986.

Shorts:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Eggers:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Molesting:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Invalid License:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

36) How much EXTRA money per trip to you think this person makes on a typical trip in the peak fishing season by

Selling shorts caught in his traps \$ _____ extra per trip

Scrubbing and selling eggers caught in his traps \$ _____ extra per trip

Molesting other's gear \$ _____ extra per trip

37) Suppose this person you are thinking of has some SHORTS on board at the dock while he is unloading (wherever he unloads). What do you estimate the odds are that fisheries wardens would catch him with the shorts at that time? (Given enforcement as it was in 1986.)

(CIRCLE THE ANSWER YOU FEEL IS CLOSEST TO THE ODDS)

1 in 1 1 in 5 1 in 10 1 in 20

1 in 50 1 in 100 1 in 500 1 in 1000

38) Now think of a slightly different situation. This time the person is out fishing on the open water and has shorts in his tanks. What is your best guess of the odds that this person would be caught by fisheries wardens at this time with shorts? (Given enforcement as it was in 1986.)

(CIRCLE THE ANSWER THAT COMES CLOSEST TO THE ODDS)

1 in 1 1 in 5 1 in 10 1 in 20

1 in 50 1 in 100 1 in 500 1 in 1000

39) Suppose this person is caught by fisheries wardens with ten (10) obviously short lobsters banded and in his tanks. Given who he is (his reputation) and the way enforcement generally operates in your area, what do you think are the odds that he will be given a VIOLATION NOTICE instead of just a verbal warning?

(CIRCLE THE ANSWER THAT COMES CLOSEST TO THE ODDS)

1 in 1 1 in 2 1 in 5 1 in 10

1 in 20 1 in 50 1 in 100 1 in 200

A VIOLATION NOTICE can result in one of four outcomes:

- (1) a Written Warning with no fine or penalty;
- (2) a Non-Criminal citation which carries with it a fine of up to \$100, payable within 21 days;
- (3) a Criminal Complaint which involves a hearing in court, where a judge determines guilt or innocence; or
- (4) Arrest of the violator, which may include seizure of gear, vessel, or motor vehicle.

LONGITUDINAL ANALYSIS OF THE IMPACT OF
OSHA HEALTH AND SAFETY REGULATIONS IN MANUFACTURING

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DRAFT: not for citation without permission from the authors.

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Longitudinal Patterns
of Compliance with OSHA Health
and Safety Regulations in the Manufacturing Sector

1. Introduction

During the 1970s the United States experienced a dramatic expansion in public controls on private behavior designed to upgrade environmental, occupational and product safety. To improve occupational safety and health, the Occupational Safety and Health Administration (OSHA) was established in 1970. Numerous studies have subsequently examined the impact of OSHA on safety performance in the U.S. As McCaffrey et. al. [7] pointed out, however, the research results pose a puzzle. On the one hand, "intensive studies of individual firms suggest that OSHA does improve safety performance and does increase safety-related investment" [p. 198]. On the other hand, "regression-based studies find fairly consistently that factory inspections by OSHA do not reduce industrial injury rates or increase [safety-related] investments." [p. 198]¹

The discrepancies may occur because the effect of OSHA is relatively small and is swamped in the regression-based studies by statistical problems. Careful consideration of the

1. For case studies, see cites [2], [3], and [6]; for regression-based studies, see [1], [7], [8], [11], [12], and [13].

econometric studies suggests that many are subject to specification and measurement problems which are likely to bias estimates of OSHA's impact. Independent analyses conducted by safety professionals suggest that only a small percentage of accidents could be prevented by compliance with OSHA standards.² If, as a result, OSHA's effect on the total accident rate is small, the estimation problems in the econometric studies could swamp the effect.

OSHA health standards are widely believed to be more efficacious in reducing future occupational disease than safety standards are in reducing accidents. However, virtually all econometric studies to date have ignored OSHA's impact on health, because data on health effects are not readily available. This omission may produce substantial underestimates of OSHA's total effect on workplace quality.

In this paper, we analyze a unique plant-level longitudinal dataset that allows us to study OSHA's impact on health as well as safety. Derived from OSHA's enforcement MIS, the dataset includes information on citations for violating OSHA health and safety standards and on the levels of worker exposures to hazardous substances.

In this section, we briefly review previous studies of the

2. See Mendeloff [8, p. 86] for citations and discussion.

impact of OSHA, to provide a context for our analysis. The regression-based literature generally can be categorized into two methodological types. In the first set, a specific deterrence model is estimated for a plant-level data set usually covering a one- or two-year period. In the second set, a general deterrence model is estimated for industry-level data which may span the full period of OSHA's activities. The standard measures of enforcement are different for the two models: the first method estimates the impact of the occurrence of an inspection; the latter method estimates the effect of expected penalties (probability of inspection times the fine).

By focusing on the ex post reaction, the specific deterrence model emphasizes the role of inspections in providing information and, perhaps, a "management shock" stimulating the company to re-evaluate safety and health investments. The general deterrence model, on the other hand, emphasizes the importance of ex ante expectations of non-compliance penalties in promoting compliance with the regulations. These ex ante expectations may be implicit in the response to an inspection in a specific deterrence model, but the model does not allow us to measure directly the effects of policies to change expectations (for example, increasing the probability of inspection or the fine.) However, none of the current work explicitly incorporates expectations of future detection and sanctions, conditional upon past inspection-compliance performance. This limitation is common to both methodologies. However, analyzing a specific

deterrence model with longitudinal plant-level data makes it possible to differentiate plant responses on the basis of past enforcement actions.

Despite their differences, the two models both define the effect of OSHA solely in terms of responses to enforcement actions. Case studies suggest that OSHA also engenders a "general awareness" or "existence" effect, in which the existence of OSHA raises concern about occupational safety and health within corporate management and among production workers. The awareness provides additional leverage for safety directors in gaining access to corporate resources and provides leverage for unions in contract bargaining. Only one study has tested the more general model of OSHA impact, the "existence" effect [8]. In this study, Mendeloff derived injury rate predictions for the post-OSHA period 1971-1975 from pre-OSHA relationships during 1948-1970. These predictions were then compared against observed injury rates. [We discuss the results of the study below.]

As noted above, various specification and measurement problems plagued the studies. In the industry-level studies, the effect of OSHA is likely to be underestimated due to the aggregation of injury and enforcement data across diverse plants within each industry. Most studies are estimated with data aggregated to the 4- or 2-digit SIC level, except for the specific deterrence studies which analyze plant-level data using very restrictive models of OSHA impact.

Mendeloff [8] demonstrated that the more important aggregation problem, however, is aggregation over different categories of injuries. Almost all studies, both on the plant and industry levels, have employed total accident rates. In contrast, Mendeloff analyzed the determinants of disaggregated categories of injuries. For categories independently identified by safety professionals as having a high proportion of injuries caused by detectable violations of OSHA standards, observed injury rates were approximately 20% lower than injury rate predictions. The analysis of disaggregated injury rates highlights the substantial effect OSHA does have on selected injury groups.³ Because the injuries associated with violations represented a small share of total injuries (5-30% by different criteria), the effect on total injuries was small. Mendeloff's methodology is not directly comparable to the methodology of the other studies, as noted above. His atypical findings that OSHA is effective in selective circumstances may be due in part to modelling an "existence" effect for OSHA.

3. Mendeloff faced the difficulty of distinguishing the "OSHA existence" effect on reducing accidents during the 1970s from the effects of other contemporaneous occurrences (not captured in the exogenous variables in the equation.) The most important omission in the model is workers' compensation benefits: his model does not capture the rapidly increasing workers compensation benefits during this time, which provides incentives to firms to reduce accidents but also provides incentives to injured workers to report more of their accidents. In empirical studies, the reporting effect generally swamps the deterrence effect on accident rates. If this pattern holds in this context, the omission yields an underestimate of the OSHA deterrence effect with his study methodology.

However, the use of disaggregated categories of accidents is probably the more important factor, because his results are comparable to those in previous studies for total injuries.

Bartel and Thomas [1] estimated a general deterrence industry-level model, in which they estimated separately the effect of OSHA enforcement on company compliance and the relationship between compliance and injury rates.⁴ The new result in their analysis is that increasing enforcement intensity appeared to be positively associated with greater compliance. Because they used aggregate injury rate data, it is not surprising that the relationship between OSHA violations and the injury rate was small and imprecise in their study.

Many studies are subject to a variety of estimation problems in addition to aggregation bias. The exclusion of workers' compensation variables will tend to produce underestimates of the impact of OSHA in either general or specific deterrence models explaining accident rates⁵ (though not with the Mendeloff methodology, as discussed in footnote 1.) Some studies have suggested that injury rates are measured with error.⁶

4. The third equation in their model characterizes the determinants of inspection rates. We will not discuss that part of the analysis, because it is not germane to our concerns here.

5. Russell [10] and Robertson and Keeve [9] demonstrate the importance of this mis-specification.

6. McCaffrey et. al. [7] discuss this issue.

Furthermore, the data series on inspection rates and injury rates are highly auto-correlated, which poses a serious challenge in identifying causal effects, particularly in models with lagged enforcement variables. Such specification problems could produce unstable parameter estimates across time periods.⁷ As noted above, these several estimation problems could prevent detection of the presumed small effect of OSHA on total accident rates.

The interesting question that has not been addressed in the literature is, what is the effect of OSHA on occupational health quality produced in firms? Health standards are widely hypothesized to be more closely associated with the production of health quality than the safety standards are with safety quality. The fundamental requirement of the health standards is to reduce exposures below the permissible exposure limit [PEL]. Given that exposure levels are generally considered to be a reasonable proxy for future incidence of occupational disease, the association between the standard and occupational disease prevention appears to be very close. By focusing solely on safety, analysts have ignored the more likely locus of OSHA impact. Furthermore, the Bartel and Thomas results showing that enforcement intensity is strongly associated with safety compliance should be a good portent of the potential effects of OSHA on health quality, given that OSHA health standards are

7. This problem may be the cause of Viscusi's [12] unstable estimates of the OSHA effect in his recent article.

closely associated with health quality.

The first analysis reported in this paper assesses the impact of OSHA enforcement activities in both the health and safety areas. We have created a unique dataset with longitudinal records for individual plants for 1972-83. With this dataset, we examine the inspection history of individual plants to determine whether the number of OSHA citations has declined with repeated inspections. Because no plant-level injury rate information [disaggregated or not] is available to us, we cannot attempt to replicate the Mendeloff results regarding the relationship between enforcement and injury rates. However, we do have a direct proxy for the future incidence of occupation disease: the measures of workplace exposures to health contaminants collected during health inspections. Furthermore, we have argued that compliance with the health standards is also a reasonable secondary proxy for health-related performance, unlike for safety-related performance.

The second analysis focuses solely on OSHA's impact on health. We examine the impact of OSHA enforcement on two measures of health performance: citations of OSHA standards and worker exposures to hazardous substances.

The next section of the paper presents a simple model of enforcement and compliance. The third section describes the data used in the analysis. The fourth section presents the results of the two analyses, and the final section discusses the